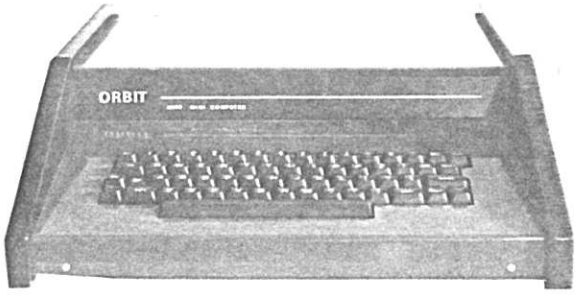
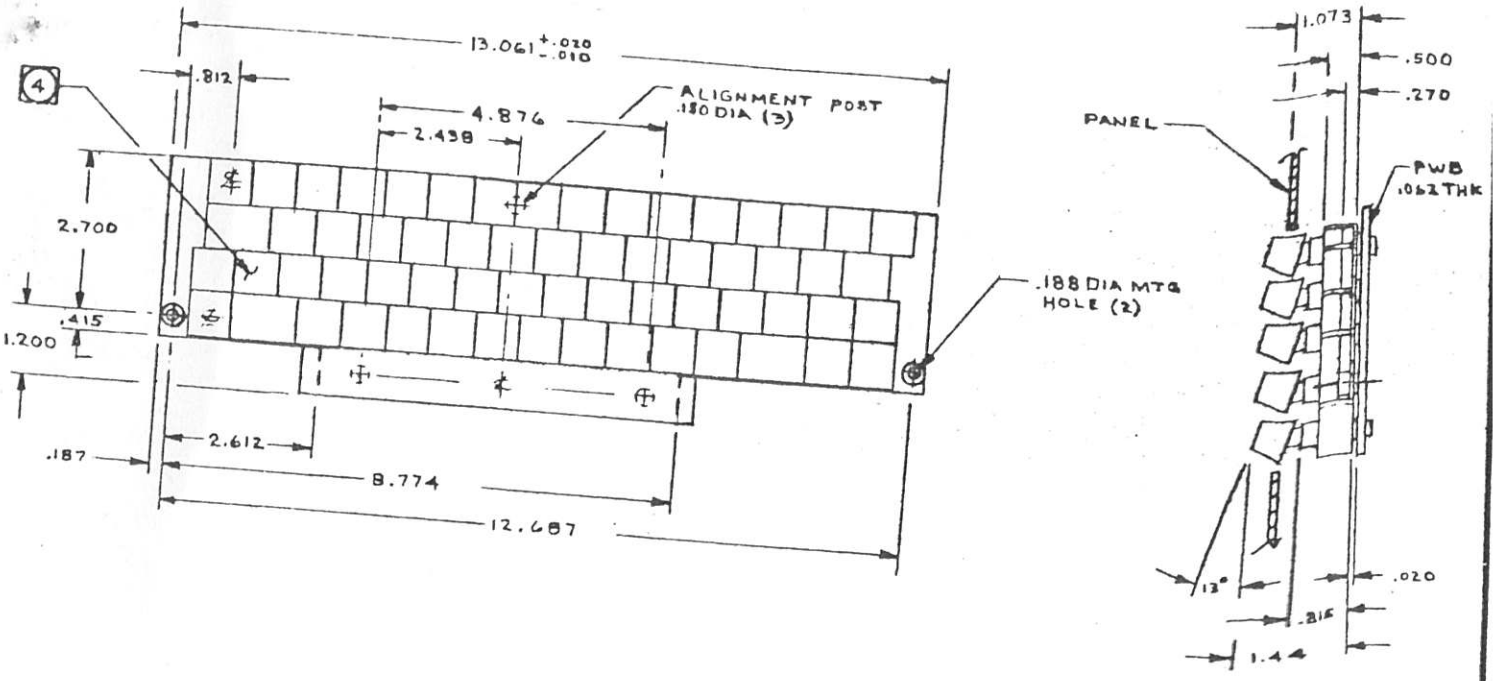
2650 Micro Computer

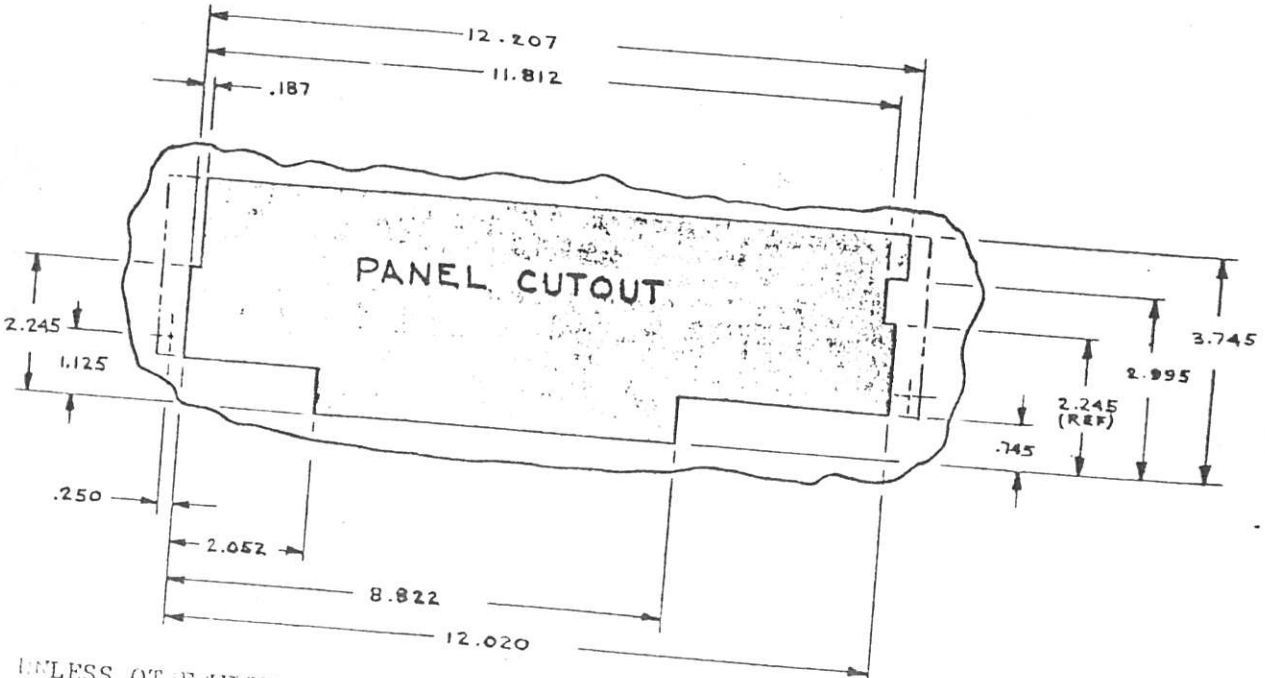
# 2650 DATA




*Manufactured and marketed by* ORBIT ELECTRONICS *Auckland.*

ORBIT ELECTRONICS
P.O. BOX 7176,
AUCKLAND.



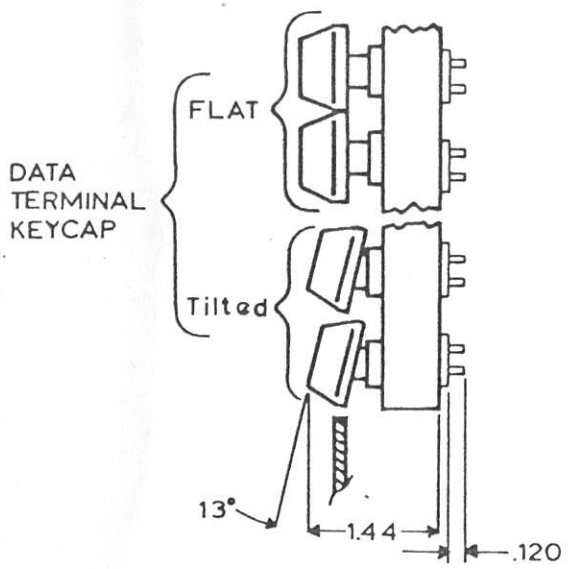




UNLESS OTHERWISE SPECIFIED
REF SEE HTC STD PROFILE
FOR ELECT AND/OR MECHANICAL SPEC.
KEYSPACING 3/4 CENTERS; 3/16-3/8 OFFSET
CONTACTS ARE CENTERED UNDER KEYCAP
THIS IS A ALTERNATE ACTION SWITCH
LOCATION

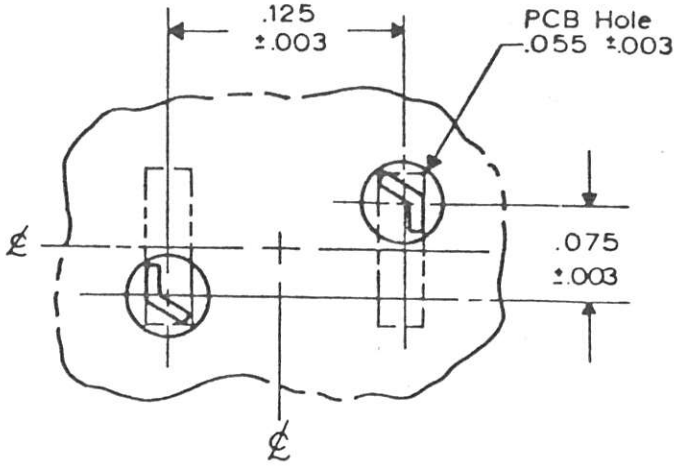
STANDARD 63 KEY

| SIZE | CODE IDENT NO. | DRAWING NO. |
|---|---|---|
| A | 27233 | DS 6300 |

SHEET




PRINTED CIRCUIT BOARD
TERMINAL CONFIGURATION




Back View of Module

## PERFORMANCE CHARACTERISTICS

### MECHANICAL

| | |
|---|---|
| KEY TRAVEL | 0.125 Nominal |
| PRE-TRAVEL | 0.075 Nominal |
| KEY PRESSURE | 50 to 100 Grams Typical (Special Available) |
| SWITCH LIFE | $20 \times 10^6$ Minimum |
| CONTACT TYPE | Quadfurcated, Form "A" Normally Open |
| KEY SPACING | 0.750 Centers Standard<br>0.600 Centers Minimum |

### ENVIRONMENTAL

| | |
|---|---|
| HUMIDITY | 95% R.H. |
| TEMPERATURE | Operating 0°C to +50°C<br>Storage −40°C to +70°C |

### ELECTRICAL

| | |
|---|---|
| BOUNCE | Typically less than 2 Milliseconds @5v DC, 10 Milliamps |
| RESISTANCE | Less than 200 Milliohm Typical |
| DIELECTRIC | 1000v RMS, 60 Hz, CKT to CKT |

### MATERIALS

| | |
|---|---|
| CONTACT | Phosphor Bronze with Western Electric #1 Gold Alloy Inlay |
| SWITCH BASE | Self-extinguishing Glass Filled Plastic |
| PLUNGERS | Self-lubricating Thermo Plastic |
| KEY CAPS | 2 Shot High Strength ABS Plastic |

HI-TEK represents over 20 years experience in design and manufacture of precision switches with a reputation for on-time delivery of quality components.

ORBIT ELECTRONICS
P.O BOX 7176.
AUCKLAND.

# A keyboard for your data terminal

In this article, the author describes how to add a keyboard and encoder, a 20mA serial interface, a VHF modulator and a power supply to the video display unit described in the February 1978 issue. Details are given showing how to use it as either a TV typewriter or a microprocessor-compatible video data terminal.

by DAVID EDWARDS

The video display unit PCB assembly described in the February issue accepts a 7 bit parallel ASCII coded digital word, and converts it into a standard video signal, suitable for displaying on a video monitor or surplus TV receiver. In order to use this assembly as either a TV typewriter or a data terminal, it is necessary to provide a keyboard and the appropriate encoder.

If you want to use a standard unmodified TV set for the display, a VHF modulator is also required. Similarly, a parallel-to-serial and serial-to-parallel converter is required for use with a microprocessor, so that signals can be passed to and from the VDU in standard 20mA loop format. This latter feature is not required for the TV typewriter.

The final requirements are a suitable power supply, and a case in which to enclose the separate assemblies. All of these additional requirements are described in this article.

The VHF modulator we have used is based on the modulator used for the video ball game described in the May 1976 issue. It is a self contained assembly, and will be described fully later in the article. All the remaining circuitry is accommodated on a single PCB, coded 78ut4, and measuring 121 x 132mm.

Referring now to the circuit diagram, we can discuss the various sections of the circuit.

The keyboard encoder is based on a National Semiconductor MOS LSI device, the MM5740AAF. This is a scanning type encoder, capable of dealing with up to 90 keyswitches arranged in an X-Y matrix. It provides for 7-bit ASCII encoding, with automatic code changing for shift and control modes.

The MM5740AAF scans all the keyswitches at a high rate, and when a key is depressed, it generates the appropriate code and makes it available at the data outputs, B1 to B7. At the same time a data strobe pulse is generated at the DS output, to indicate that a key has been pressed.

Two clock signals are required for the encoder, one a nominal 100kHz signal to drive the keyboard scanner, and the other a nominal 10Hz signal to implement the keyboard "repeat" function. These can both be derived from the main VDU board, thus saving the cost of two 555 oscillators as used in our previous VDU design (February 1977).

The outputs from the encoder use active-low logic levels, and thus require inversion using 7404 hex inverters. The inverter outputs are connected to the parallel inputs of the transmit section of the universal asynchronous receiver transmitter (UART), which then transmits them in serial form.

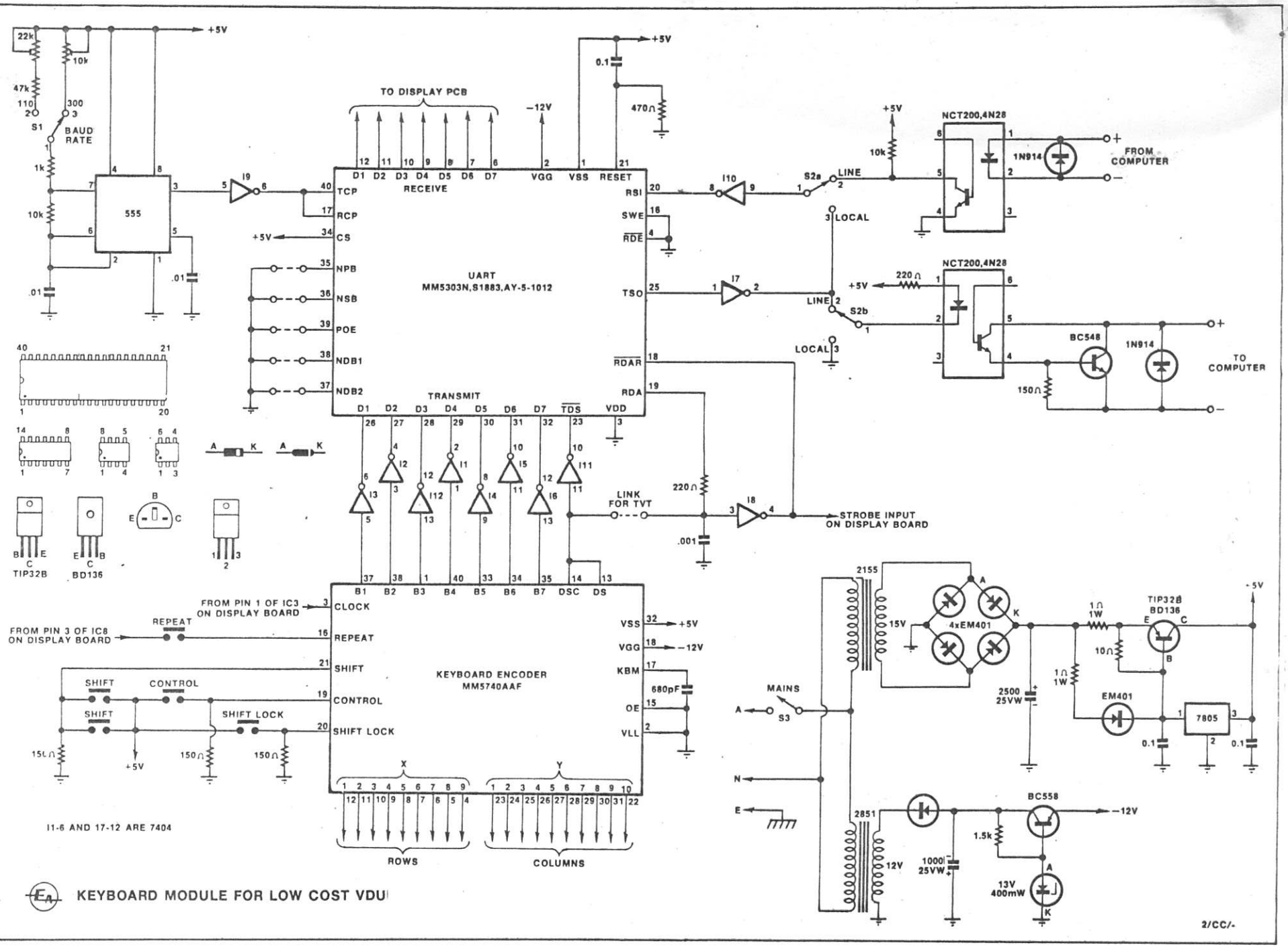
A 555 timer is used to generate the clock signals required by the UART. It is switch selectable for either a 110 or 300 baud communication rate, the two speeds being adjusted by preset pots.

Two optocouplers are used to buffer the serial input and output of the UART, to allow full isolation of the terminal from whatever system it is used with. The circuit used with the optocouplers is intended for use with 20mA current loops.

The receiver side of the UART is used to convert the serial signal returning to the terminal into the parallel signals required by the VDU board (D1 — D7). The receive data available (RDA) signal

*LEFT: The way in which a small TV set sits on top of the chassis can be seen in this photograph.*

*On the page opposite is the circuit diagram for the keyboard encoder and the serial to parallel interface.*


KEYBOARD MODULE FOR LOW COST VDU
UART
MM5303N,S1883,AY-5-1012
KEYBOARD ENCODER
MM5740AAF
555
BAUD RATE
S1
TO DISPLAY PCB
RECEIVE
TRANSMIT
LINK FOR TVT
STROBE INPUT ON DISPLAY BOARD
FROM COMPUTER
TO COMPUTER
NCT200,4N28
1N914
BC548
BC558
TIP32B
BD136
BD140
4xEM401
EM401
7805
LOCAL
LINE
S2a
S2b
MAINS
S3
FROM PIN 1 OF IC3 ON DISPLAY BOARD
FROM PIN 3 OF IC8 ON DISPLAY BOARD
REPEAT
SHIFT
CONTROL
SHIFT LOCK
ROWS
COLUMNS
I1-6 AND 17-12 ARE 7404
2/CC/-

from the UART is inverted and used to drive the strobe line of the VDU board.

Switching has been provided to enable the terminal unit to operate in either a "local" mode or a "line" mode. In the local mode, the serial output of the UART is connected directly to the serial input, allowing the unit to be used as a TV typewriter.

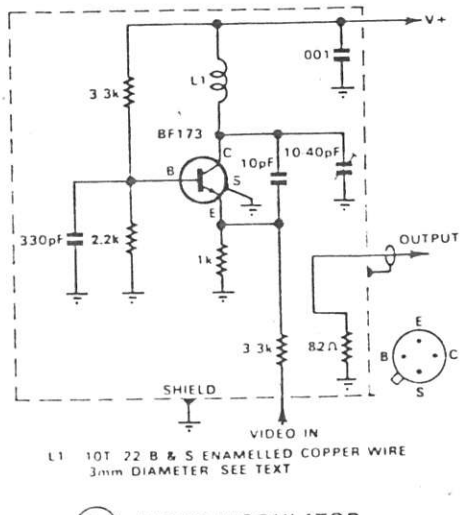
If the unit is to be used as a TV typewriter only, it is possible to dispense with the UART and its associated components. Only the keyboard encoder, the two hex inverters and the power supply components are required.

The power supply circuit is a little unusual. A total of 1.5A at 5V is required for the VDU board and the interface board, along with a —12V substrate bias supply. Two commonly available transformers are used rather than a single larger, and more expensive, unit.

The —12V supply is generated from a 2851 type transformer, with a simple active regulator to stabilise and regulate the output. The 5V supply uses a 2155 type transformer, with the regulation achieved by a three terminal IC regulator aided by a pass transistor.

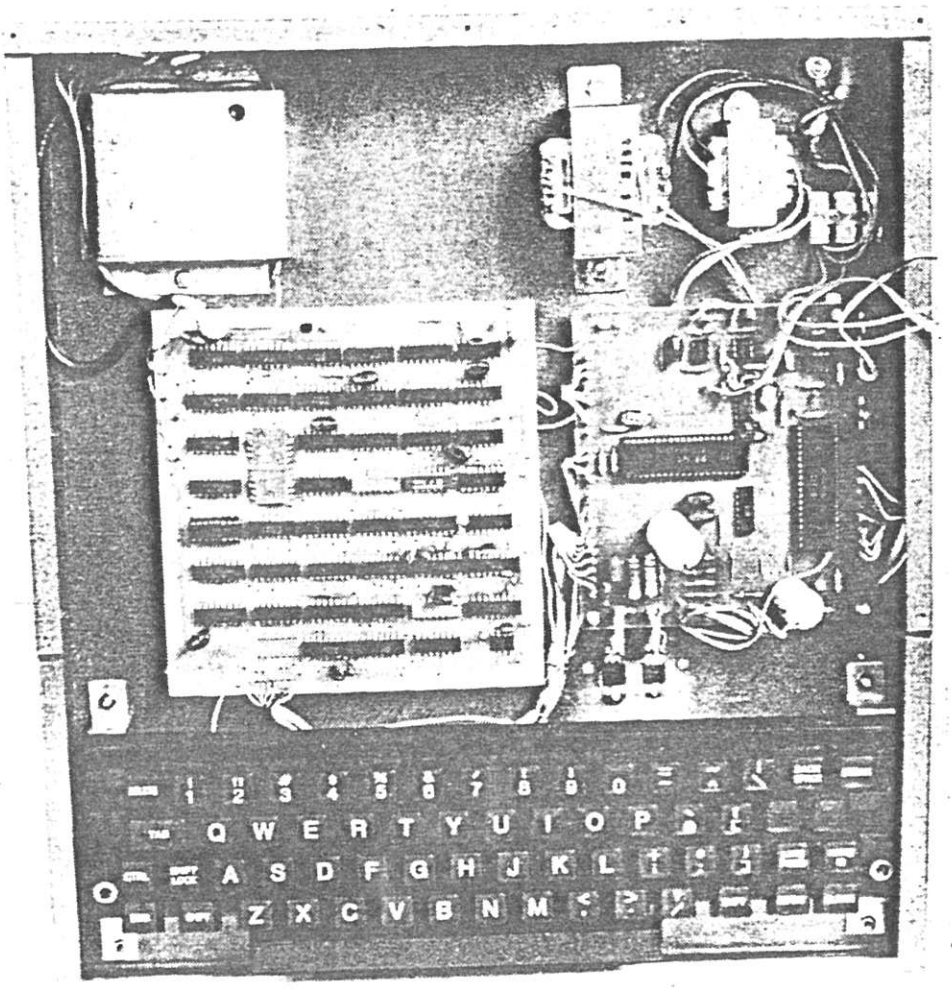
With adequate heatsinking, this regulator is capable of supplying currents of up to 2A, but is limited in the present case by the transformer to just over 1.5A.

As stated earlier, the modulator used is based on one of our previous designs, and uses the same PCB. This is coded 76m5. All components are soldered to the copper side of the PCB, which is then bolted directly to the bottom of the case. A small tinplate shield is then fitted over the complete assembly, to minimise spurious radiation.




E4 VIDEO MODULATOR

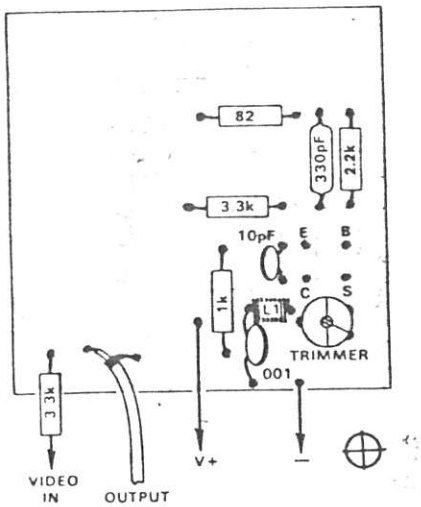
*ABOVE and RIGHT: The modulator circuit diagram and overlay diagram. Note the transistor orientation.*



*This view shows how the keytops are arranged, and the internal layout of the unit. Note the modulator shield.*

As can be seen from the photographs, the construction of the prototype is based on the metalwork and associated components used in our first video terminal, presented in the January and February 1977 issues.

The prototype case was kindly supplied by Cowper Sheetmetal and Engineering, of 11 Cowper Street, Granville, NSW 2142. It measures 360mm x 400mm 60mm, and has a sloping front with a cutout to match commonly available keyboards. The case is designed to allow a small portable TV or monitor to be placed on top, to form a complete video terminal.




The keyboard used in the prototype was supplied by Dick Smith Electronics Pty Ltd, and features gold plated contacts. It has most of the keytops required, apart from "carriage return". However two blank keytops are present, one of which can be pressed into service.

Commence construction by fitting the hardware to the case, using the photographs as a guide. The keyboard is mounted on two brackets, and should be fitted carefully so that all keys clear the cover cutout. Note that it may be necessary to extend the cutout slightly in the top right hand corner.

The two main PCBs are mounted on standoffs, immediately behind the keyboard. The transformers are mounted in the rear right hand corner, along with the associated mains wiring. The three miniature toggle switches are mounted on the lid of the case, just above the right hand side of the keyboard.

The modular PCB mounts in the rear left hand corner, near the two coaxial

connectors. It is bolted to the case using a single machine screw and nut, which must pass through the earthy pattern.

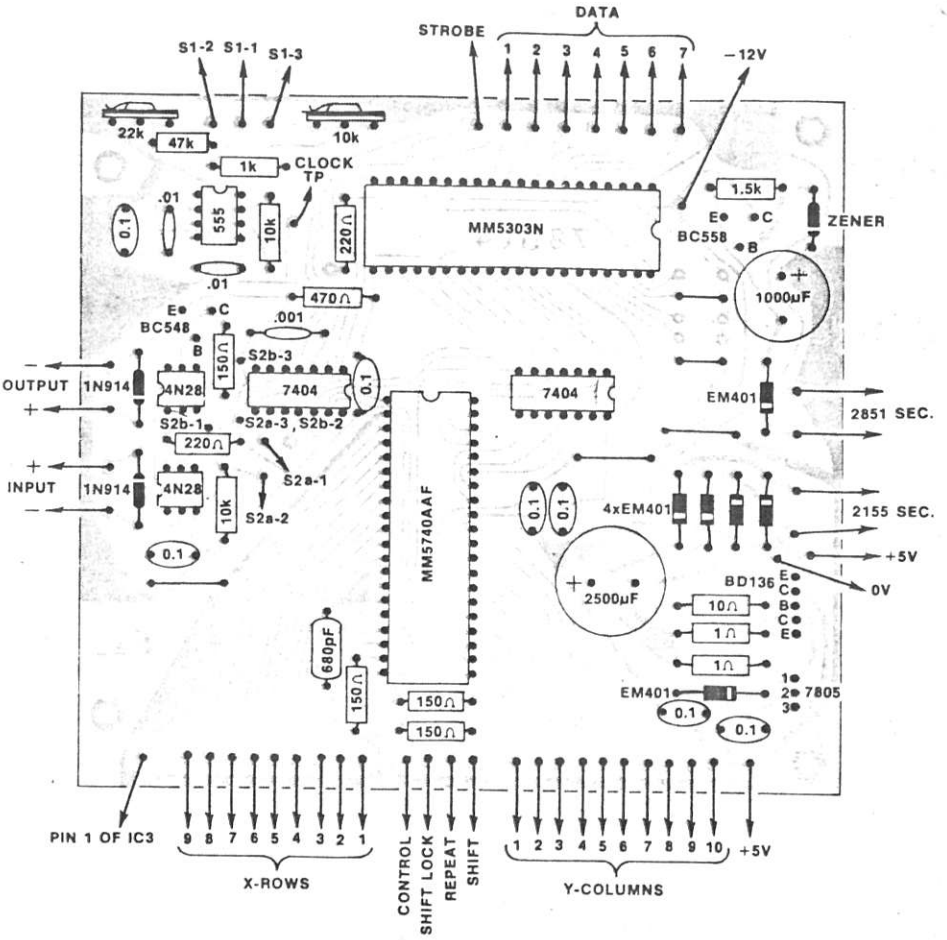
Once all the hardware is complete, the PCBs can be assembled. If you use sockets for the two 40 pin devices on the keyboard PCB, make sure they are of good quality. Sockets should not be necessary for the TTL ICs, the 555 or the optocouplers. We recommend that PCB pins be used for all external connections.

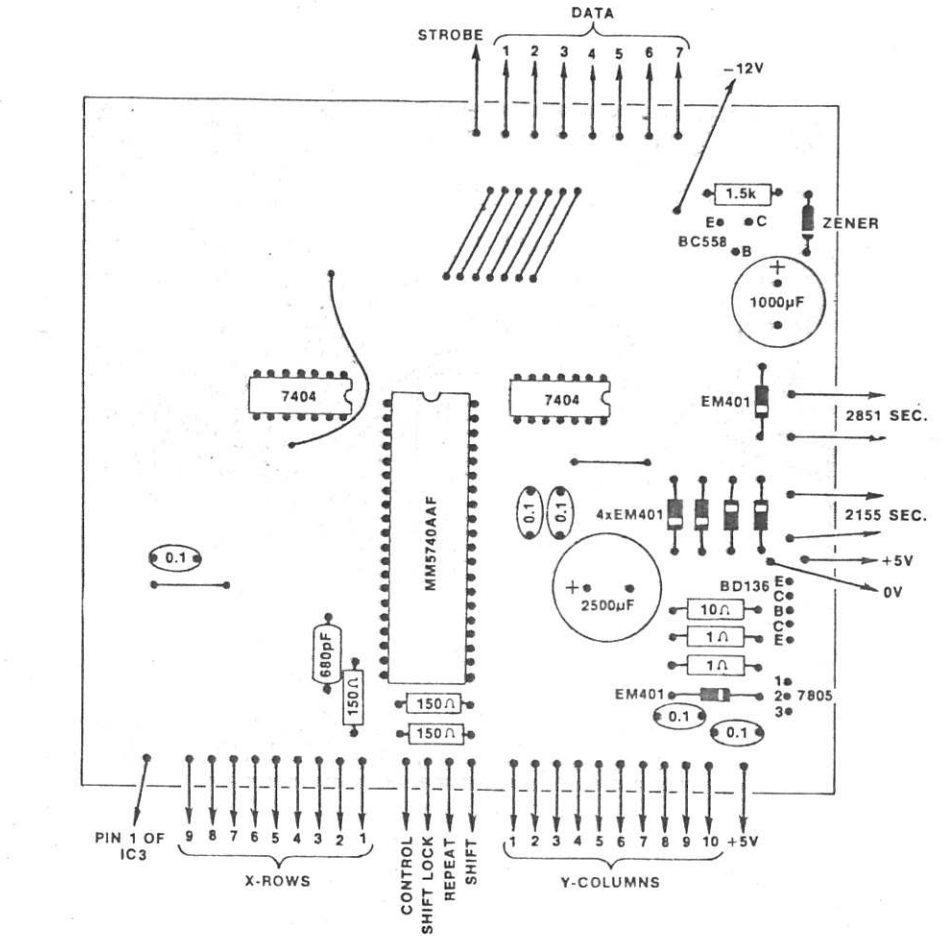
The three-terminal regulator and the pass transistor must be mounted on the base of the case, to provide adequate heatsinking. Use steel wool or emery paper to clean the paint off, to improve thermal conductivity, and use silicone grease if possible. The pass transistor must be insulated from the case, using the appropriate mica washer and insulated bush.

Note that the base connections of the two transistors specified are different. The BC136 mounts as shown in the overlay diagram, while the TIP32B mounts to the three lower holes of the group of five.

Before commencing to wire the keyboard, ensure that all the keytops are in the correct locations. Then wire the eight X rows and the 10 Y columns, using the keyboard wiring diagram as a guide. Use tinned copper wire, with insulation sleeves where crossovers are required. Use a small soldering iron, and do not heat the contacts unnecessarily, as the plastic of the switches may distort and upset the switching action.

*ABOVE RIGHT: Use this overlay diagram if you are building the complete terminal.*
*RIGHT: Use this overlay for the TV typewriter-only version.*



# ADDITIONAL PARTS REQUIRED FOR DATA TERMINAL

*SEMICONDUCTORS*
1 MM5303N, S1883, AY-5-1012 or similar UART
1 MM5740AAF keyboard encoder
2 7404 inverters
1 555 timer
2 4N28, NCT200, TIL114 or similar optocouplers
1 7805 5V three terminal regulator
1 BD136, TIP32B or similar PNP transistor
1 BC558 or similar PNP transistor
1 BC548 or similar NPN transistor
2 1N914 or similar silicon diodes
6 EM401 or similar silicon diodes
1 13V 400mW zener diode

*RESISTORS*
(all ¼W unless stated otherwise)
1 10k trimpot
1 22k trimpot
2 1 ohm 1W, 1 10 ohm, 4 150 ohm, 2 220 ohm, 1 470 ohm, 1 1k, 1 1.5k; 2 10k, 1 47k

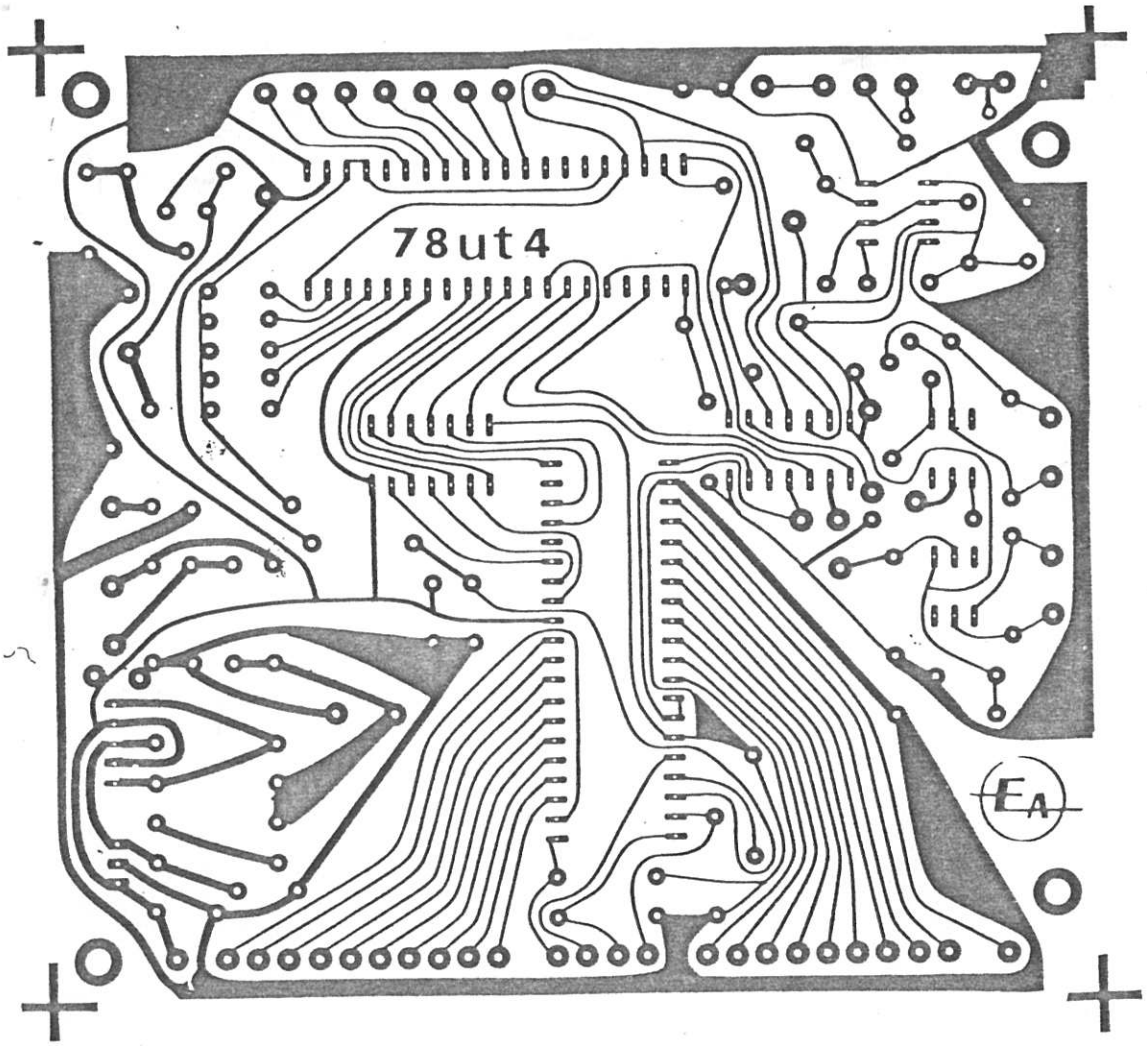
*CAPACITORS*
1 680pF polystyrene
1 0.001uF polyester
2 0.01uF polyester
7 0.1uF polyester
1 1000uF 25VW PCB electrolytic
1 2500uF 25VW PCB electrolytic

*MISCELLANEOUS*
1 printed circuit board, coded 78ut4, 121 x 132mm
1 ASCII-type keyboard assembly (see text)
1 Case, 400 x 360 x60 mm with sloping front (see text)
2 SPDT miniature toggle switches
1 DPDT miniature toggle switch
2 40 pin DIL sockets
2 Belling-Lee RF connectors
1 Output connector (see text)
1 Transformer, 240V to 15V @ 1A, DSE2155, A&R 2155 or similar
1 Transformer, 240V to 12V @ 150mA, DSE 2851, A&R 2851, PF 2851 or similar
8 PCB standoffs
4 rubber feet
1 Mains cord, 3 pin plug, grommett, cord clamp and terminal block
Rainbow cable, tinned copper wire, shielded cable, hookup wire, solder, machine screws and nuts, insulated mounting kit for plastic power transistor, silicon grease (heat sink compound)

*ADDITIONAL PARTS REQUIRED FOR MODULATOR*
1 Printed circuit board, coded 76m5, 65 x 65mm
1 BF173 NPN transistor
1 82 ohm, 1 1k, 1 2.2k, 2 3.3k ¼W resistors
1 10pF NPO ceramic capacitor
1 0.001uF ceramic capacitor
1 10 — 40pF trimmer capacitor
1 330pF polystyrene or ceramic capacitor
1 tinplate shield (see text)
22 B & S enamelled copper wire

*NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may generally be used provided they are physically compatible.*

*BELOW: This is the PCB pattern for the encoder board, shown actual size.*



# A low cost video display unit

Here is a new design for a low cost video display unit, capable of displaying data from a microcomputer on a standard TV receiver or monitor. It displays 16 lines of 32 characters and offers both flashing cursor and a destructive backspace facility. All timing is derived from a crystal oscillator, and no setting up is required.

**by MICHAEL O'NEILL**

Physics Department,
Newcastle University

This Video Display Unit (VDU) was designed primarily for the microprocessor system user, who requires a video terminal of minimum complexity to enable him to communicate with his system. Therefore many of the unnecessary features of commercial style VDU's were abandoned in order to provide a cheap but effective video terminal for such applications.

Sixteen lines of 32 characters was selected as the screen format which allows for adequate display of program steps. With continuous roll-up facility, the user can see at least his last 16 lines of information. The cursor, indicating the position of the next character is fixed permanently on the bottom line (line 16). Carriage return and line feed (non-print characters) are decoded and these are normally all that would be required for a basic unit. However, a back space control function has been included mainly for the benefit of those who might use such a unit as a TV typewriter. This control allows editing of the bottom line before a line feed is given. Back space actually types a space in the location of the cursor after moving it back one character position.

The VDU uses all standard readily available TTL IC chips, except for six CMOS memory chips and the character generator chip.

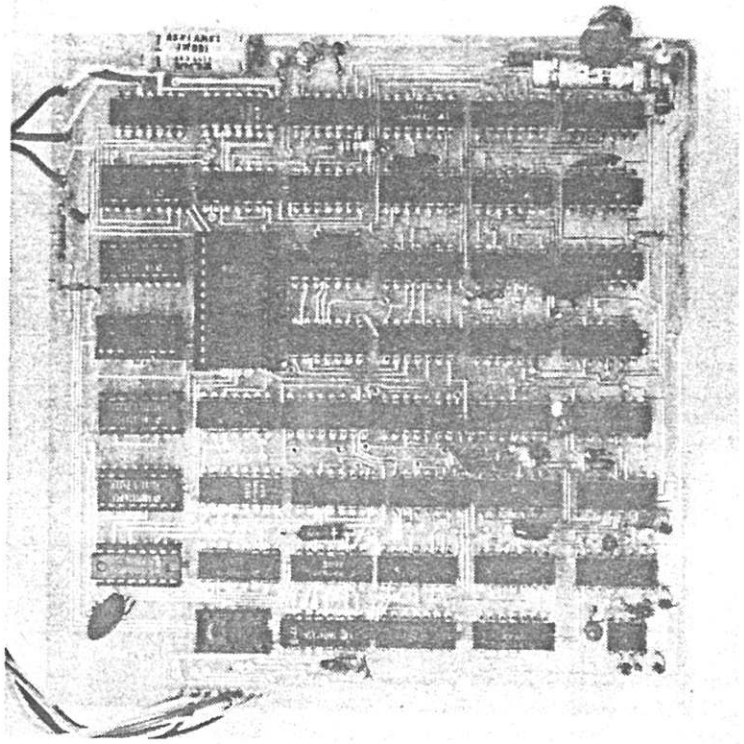
The method of actually displaying a character on a TV screen will not be described in detail here, as reference to the issue of EA for January 1977 should make this clear. The VDU described here uses the same character generator IC described in the earlier article (i.e., the 2513), and hence allows for the display of the full 64-character subset of ASCII known as "6-bit ASCII". This is the same character set displayed on most teleprinters.

A 4.7MHz crystal oscillator provides all of the clock pulses for the VDU. As can be seen from the block and circuit diagrams, this base frequency is divided down to produce the horizontal and vertical sync pulses required by the TV set. The 4.7MHz signal is also used to clock the output shift register used to convert the parallel "row data" from the character generator into the serial data required as video information by the TV display.

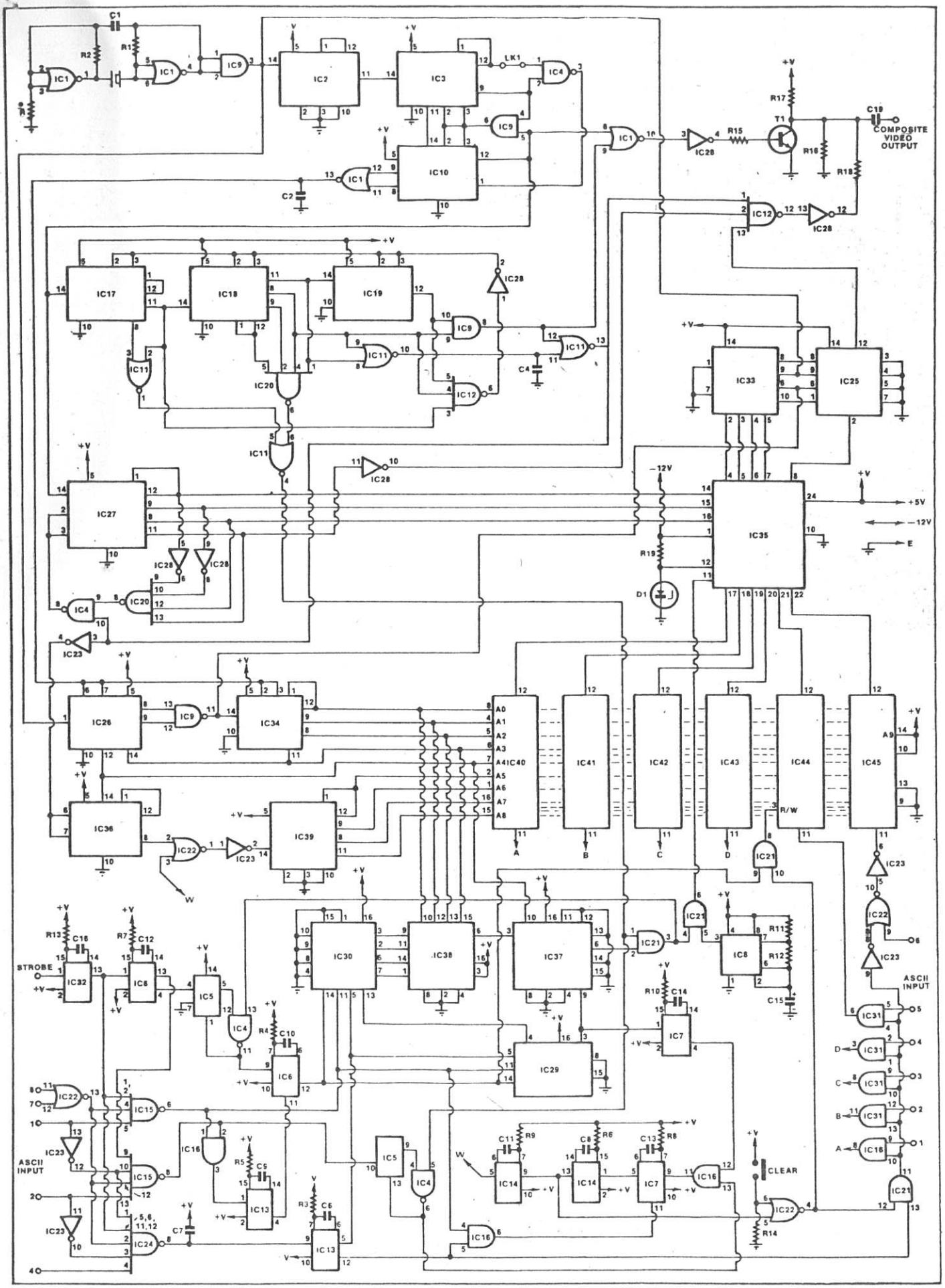
Incidentally it has been found that a 4.43MHz crystal of the type used in the subcarrier oscillator of colour TV receivers may be used instead of the nominal 4.7MHz crystal. This can be worthwhile, as the 4.43MHz crystal is generally cheaper and easier to obtain. Naturally when the lower frequency

## SPECIFICATION

VDU displays the 6-bit ASCII character set, in 16 lines of 32 characters. All timing derived from a crystal-locked oscillator; no setting up required. Continuous line scrolling of display. Maximum input data rate 50 characters/sec. Destructive back space facility for editing. Flashing cursor indicates next character position.
Uses standard TTL ICs for low cost.



*At left is the assembled PC board. Note that the version shown here uses a 100pF capacitor paralleled by a 30pF trimmer in place of the crystal.*


C1
R1
R2
IC1
IC9
IC2
IC3
LK1
IC4
IC10
C2
R17
T1
C19
COMPOSITE VIDEO OUTPUT
R15
R16
R18
IC28
IC12
IC17
IC18
IC19
IC20
IC11
C4
IC33
IC25
IC27
IC26
IC34
IC35
R19
D1
+5V
-12V
E
IC36
IC39
IC22
IC23
W
A0
A1
A2
A3
A4
A5
A6
A7
A8
IC40
IC41
IC42
IC43
IC44
IC45
A9
R/W
A
B
C
D
IC21
IC30
IC38
IC37
IC8
R11
R12
C15
R10
C14
IC7
IC29
R13
C16
R7
C12
STROBE
IC32
IC5
R4
C10
IC6
ASCII INPUT
IC31
IC15
IC16
R5
C5
IC13
R3
C6
C7
IC24
5,6, 11,12
C11
R9
C8
R6
C13
R8
IC14
CLEAR
R14

crystal is used, both of the TV sync pulse frequencies are lower also, but most TV sets seem to be able to lock onto them quite easily. As the vertical frequency becomes 45.5Hz instead of 50Hz, some sets may produce a small amount of horizontal wavering or "snaking", particularly if there is some 50Hz ripple getting into the vertical oscillator from the receiver's power supply.

If such an effect is experienced and found annoying, then a 100pF capacitor with a 30pF trimmer in parallel may be substituted for the crystal if a 4.7MHz crystal is not available. The trimmer capacitor can be varied until the TV set locks onto the VDU sync pulses. Further trimming may be required to obtain a steady display.

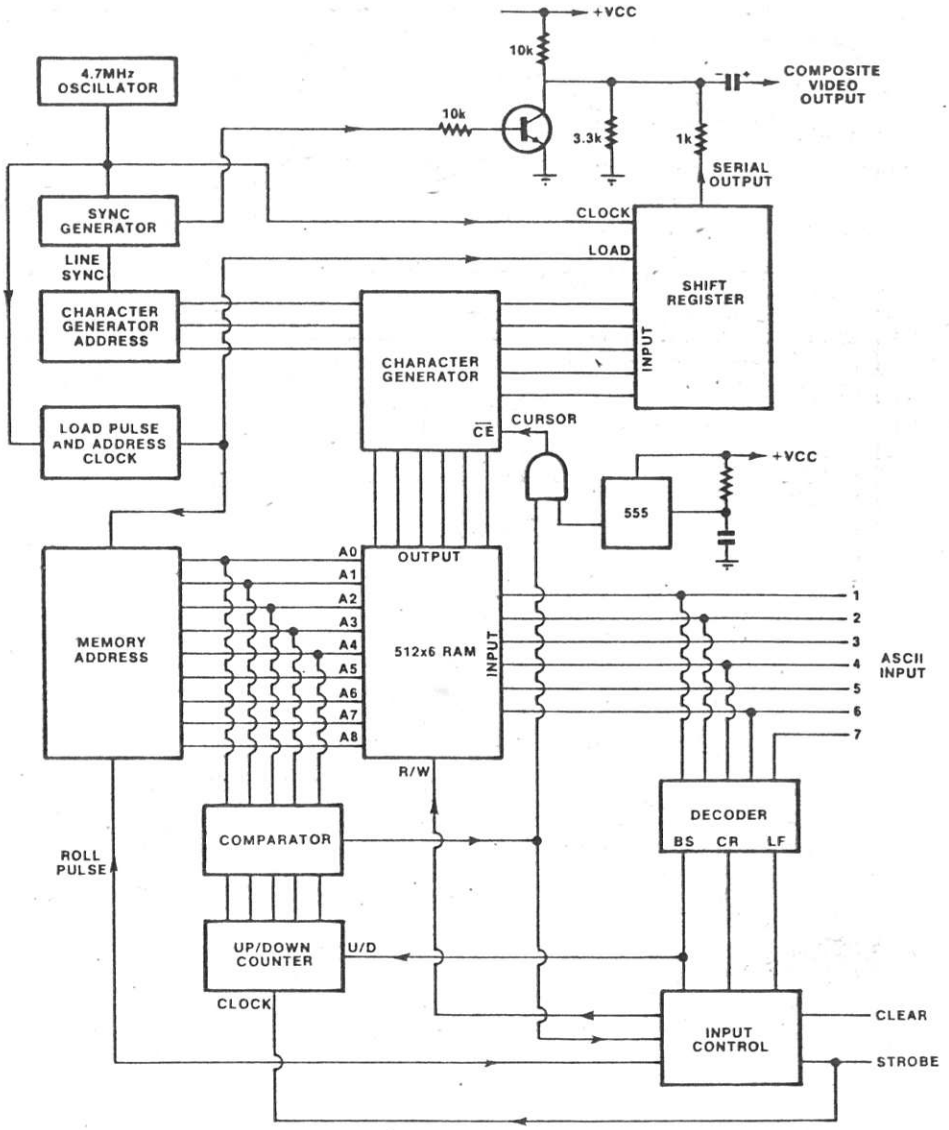
Note that if this capacitor is used, a 220 ohm resistor is required as an addition between pins 2 and 3 (joined together) on IC1 and ground. This is indicated on the circuit diagram as R* and can be soldered onto the board, vertically, from the appropriate side of R2 and the outer ground line.

A further chain of frequency dividers generates the line address information for the character generator and the load pulses for the shift register. One load pulse occurs for every six clock pulses given to the shift register, thus loading it with the required five bits of data for a character row and also giving a single "dot" space between characters. Since this load pulse occurs for each character across the screen (i.e. 32 times for each horizontal TV scan) it becomes the ideal clock pulse for the memory address.

Nine address lines are required to address the memory, which holds each character to be displayed on the screen in its ASCII code. The memory is re-addressed each frame and therefore a character remains in its particular location in memory until changed by an external control signal. The memory consists of six 2102, 1k x 1 RAMS, six being required to hold the six bit ASCII code. This provides 1024 6 bit words, but only 512 are used.

The outputs of the memories are connected directly to the character generator. The memories are normally held in the read mode and each time the address changes, the outputs from the memories change to provide a six bit ASCII code for the character generator.

As just mentioned, an external control signal is required to change data held in memory. To do this we must have a written command, together with an indication as to where in memory its contents are going to change. Memory location indication is achieved by comparators and a set of counters that duplicates the memory address. This extra set of counters are advanced one count by the input strobe pulse, which indicates that a new character is being entered either from a keyboard or a computer. The comparator gives an output when the memory address equals the count on the duplicated set of counters, and this output is used to gate the ASCII input into the correct location in memory.




*Above shows the block diagram, while at right is the component overlay pattern.*

Because of this gating technique, a character can only be written into memory every frame, which immediately indicates a baud rate limitation of 500 baud. Since this VDU was designed for microprocessors, this modest baud rate should not be a problem as the VDU will operate at the 110, 150 or 300 baud rates used by most debug ROMS in microcomputers.

If the output of the comparators is fed to the CE-bar input on the character generator chip, it disables the chip for that particular location, and therefore a single bar is generated on the screen. This occurs instead of generating a character and therefore a cursor appears. Since the cursor appears permanently on the 16th line, only five of the nine address lines need to be compared, thus controlling the 32 positions along the line. The blinking effect of the cursor is achieved by gating the control signal with a low frequency astable multivibrator; a 555 timer has been used for this purpose.

At this point it should be clear that we now have a "page" of information displayed on the screen with a cursor indicating the next character position. Let's now take a look at how the scrolling of lines is achieved.

The memory address counters can be divided into two parts. The first five address lines control the 32 characters across each of the 16 lines, while the 16 lines themselves are controlled by the last four address lines. If at any time an extra clock pulse is given to this last address counter it would add an extra count and thus change the character line position as they appear on the screen. If the pulse is applied to this counter during the time that there is no

# PARTS LIST

### INTEGRATED CIRCUITS

| | | |
|---|---|---|
| IC1 - 7402 | IC16 7408 | IC31 7408 |
| IC2 - 7493 | IC17 7493 | IC32 74123 |
| IC3 - 7493 | IC18 7493 | IC33 7495 |
| IC4 - 7400 | IC19 7493 | IC34 7493 |
| IC5 - 7474 | IC20 7420 | IC35 2513 |
| IC6 74123 | IC21 7408 | IC36 7492 |
| IC7 74123 | IC22 7402 | IC37 7485 |
| IC8 - 555 | IC23 7404 | IC38 7485 |
| IC9 - 7408 | IC24 7430 | IC39 7493 |
| IC10 - 7493 | IC25 7495 | IC40 - 2102 |
| IC11 - 7402 | IC26 7492 | IC41 - 2102 |
| IC12 - 7410 | IC27 7493 | IC42 - 2102 |
| IC13 74123 | IC28 7404 | IC43 - 2102 |
| IC14 74123 | IC29 74191 | IC44 - 2102 |
| IC15 - 7420 | IC30 74191 | IC45 - 2102 |

### RESISTORS

| | | | |
|---|---|---|---|
| R1 | 470 ohms | R11 | 10k |
| R2 | 470 ohms | R12 | 120k |
| R3 | 22k | R13 | 10k |
| R4 | 6.8k | R14 | 470 ohms |
| R5 | 22k | R15 | 10k |
| R6 | 6.8k | R16 | 3.3k |
| R7 | 6.8k | R17 | 10k |
| R8 | 39k | R18 | 1k |
| R9 | 22k | R19 | 680 ohms |
| R10 | 6.8k | R* | 220 ohms |

### CAPACITORS

| | | | |
|---|---|---|---|
| C1 | .01uF | C12 | 330pF |
| C2 | 330pF | C13 | .33uF tant. |
| C3 | .1uF | C14 | .022uF |
| C4 | 330pF | C15 | 4.7uF tant. |
| C5 | .1uF | C16 | .027uF |
| C6 | 3.3uF tant. | C17 | .1uF |
| C7 | .001uF | C18 | .1uF |
| C8 | .022uF | C19 | 47uF 25V electro. |
| C9 | 3.3uF tant. | C20 | .1uF |
| C10 | 22pF | C21 | .1uF |
| C11 | .082uF | | |

CRYSTAL 4.7MHz
or 100pF capacitor and 30pF trimmer

D1 BZX79C5V1

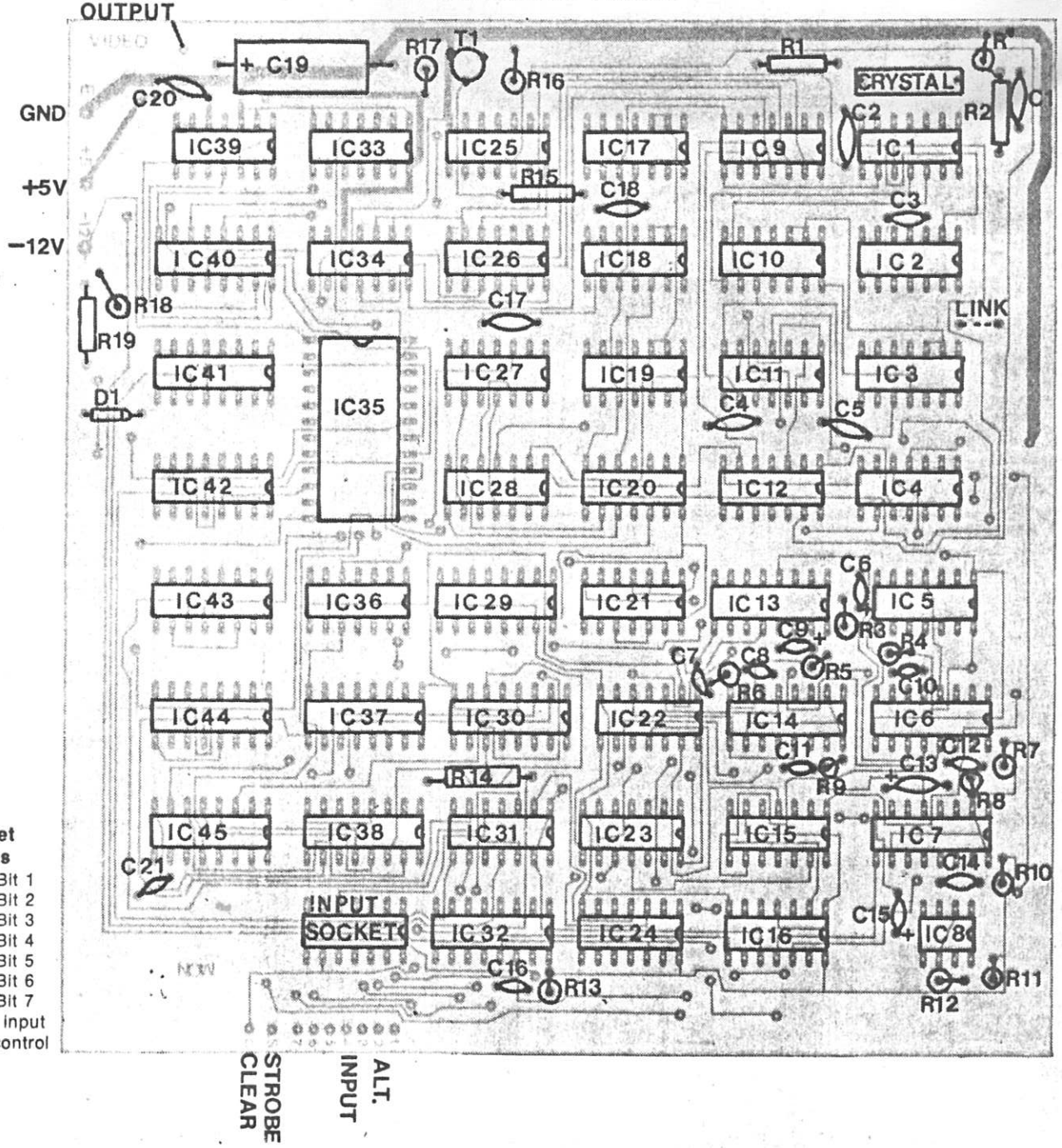
T1 BC109

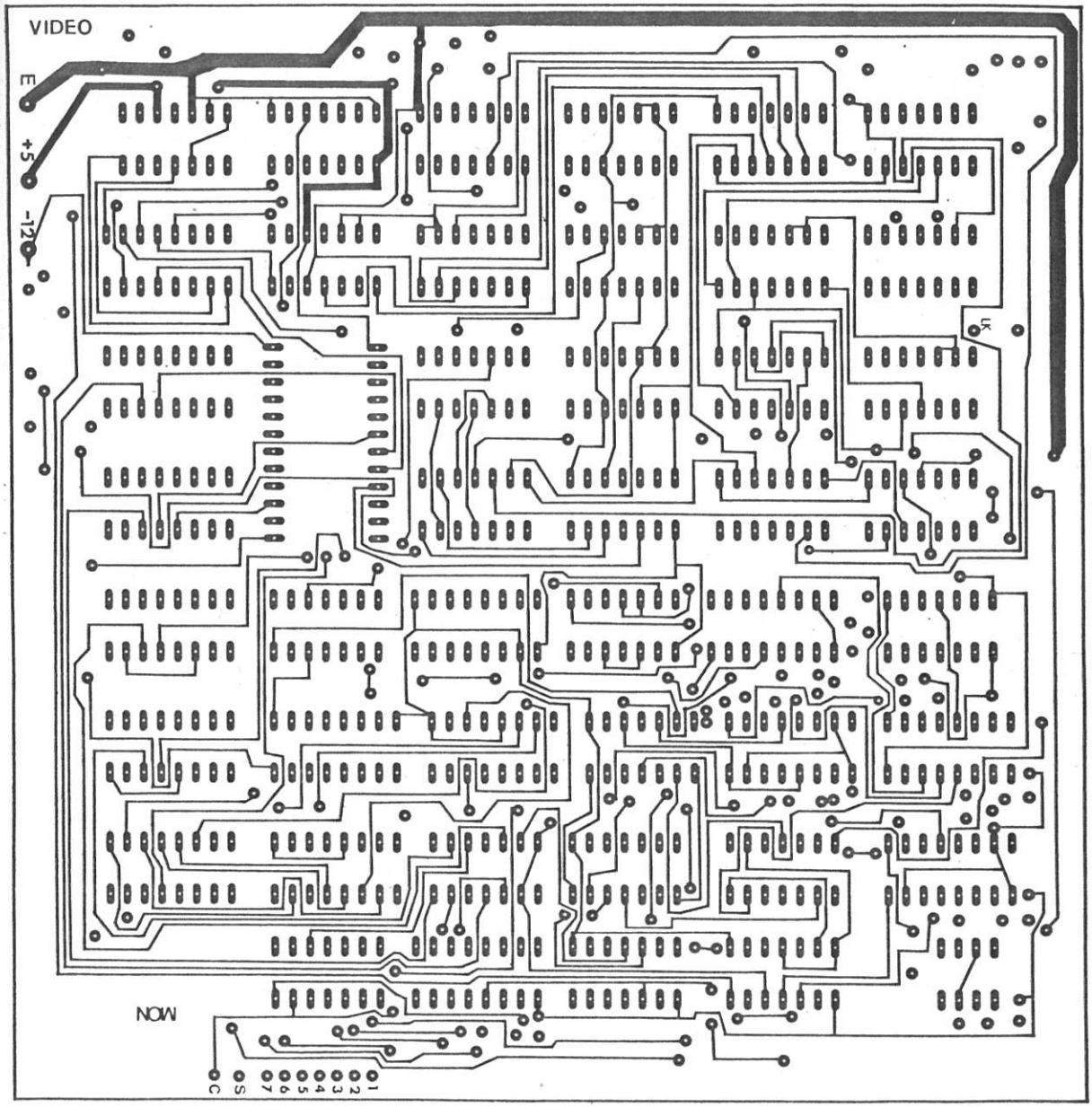
**Input Socket Connections**

Pin 1 ASCII Bit 1
Pin 2 ASCII Bit 2
Pin 3 ASCII Bit 3
Pin 4 ASCII Bit 4
Pin 5 ASCII Bit 5
Pin 6 ASCII Bit 6
Pin 7 ASCII Bit 7
Pin 8 Strobe input
Pin 9 Clear control

COMPOSITE VIDEO OUTPUT

COMPONENT LAYOUT






*Actual size reproduction of the PC pattern on the component side of the board.*

display on the screen (i.e. the time between frames) then the next time a frame appears on the screen it will start at one extra character line due to this extra count. This extra clock pulse is generated at the end of a line, or when line feed is detected, and gives the scrolling effect.

When roll-up does occur another pulse is also generated which applies the ASCII code for a space to the memories and a write command is given at the same time. This immediately gives a clear line on line 16, to type onto after the previous line is rolled up.

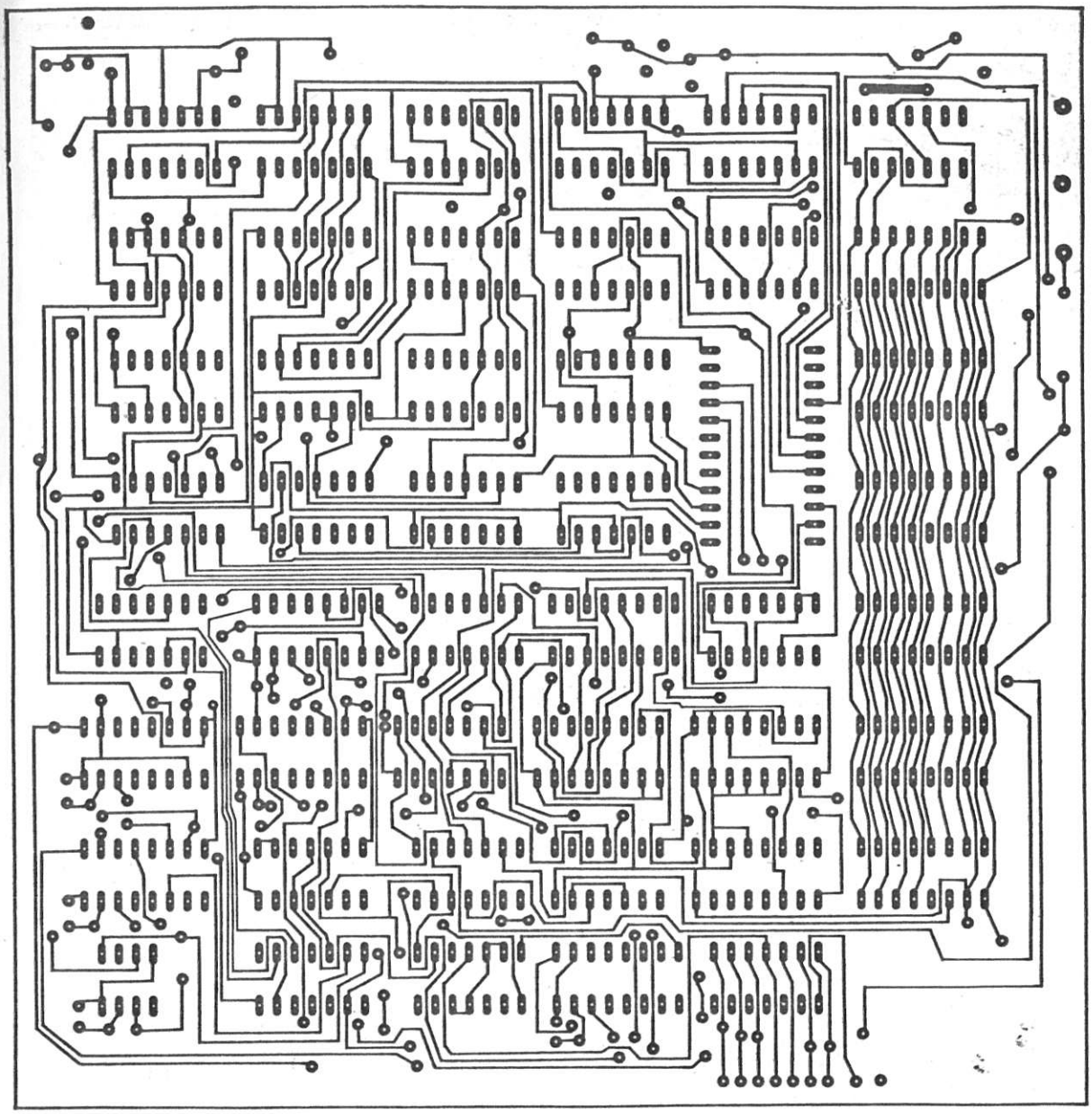
A decoder is used to detect when carriage return, line feed, or back space information is given to the VDU. The control bit in the ASCII code — bit 7, is used for this purpose.

The video information from the shift register is fed to the output of transistor T1 via a 1k resistor, and is mixed with the inverted sync pulses which are applied to the base of the transistor. The 10k and 3.3k resistors provide the correct 1:3 ratio for sync and video information. This composite video is then output via an isolating capacitor and is suitable for applying to any video amplifier employed in standard TV sets.

Experience has shown that the video output from the VDU is suitable for applying to the grid or the base (depending on whether valve or solid state) of the video driver in a TV set, without any alteration or disconnection of any components.

When checking for this input, one should ensure that the take-off for the sync separator is after this stage of amplification in the TV receiver.

There is absolutely no setting up required with the VDU. Random characters should appear on the TV screen as soon as power is switched on. To enable a clear screen when first turned on, a clear input has been provided on the PC board. It requires a switch to the +5V rail, or a logic "1" applied to it. This can be obtained from an unused key on the terminal's keyboard, giving manual clearing, or alternatively by means of a capacitor to



*The PC pattern for the reverse side of the board, again shown actual size.*

the +5V supply rail, to give automatic clearing on power-up. A 47uF tantalum should work.

A link, LK, has been provided on the PC board to provide an option regarding horizontal positioning of the VDU display. With the link out, the video information is generated in the centre of the period between horizontal sync pulses, giving a display which should be centred on most TV sets. If, however, it is found that the display is not in the centre of your TV screen, this link can be inserted and the whole picture will be shifted about three character widths to the right of the screen.

The printed circuit board for the VDU measures 155 x 160 mm and has an input socket facility where the required input data lines can be entered via a 14 pin DIP connector, using flat ribbon cable. This makes for a very neat connection. However, for those wishing to keep costs down, the same inputs are available at the edge of the PC board where wires can be soldered directly to the copper. The strobe input is triggered by a negative edge; if this is not available, an inverter on this line would be required.

Power supply requirements are +5 Volts at 1.2 Amps and -12 Volts at around 40mA. The higher +5V supply current is required because of the TTL chips used. Three terminal regulators rated for 1.5 Amps are adequate for this voltage supply.

A UART has not been included on the PC board because the VDU was considered to be a separate self-contained control system which accepts parallel data only, and if serial data is required by a microcomputer system then an external device such as a UART should be added. Parallel data is also acceptable to some microprocessors and makes for easier programming.

Editor's Note: For those who do wish to add serial interfacing and a keyboard, to produce a complete self-contained terminal, we hope to supply the necessary information shortly.